Summary
A Review on the Contiguity Effect in Episodic Memory

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Tulving (1972) coined the term "episodic memory" to refer to the ability to remember personal events consciously, including both the content and spatiotemporal context of the event, leading to a "mental time travel". Episodic memory can be studied using recall or recognition tasks. In recognition tasks participants are given a set of stimuli and later asked to distinguish the ones they studied from new items. In the other hand, in free recall, participants are asked to recall the words they studied in the order they want, and this task is important because it shows how individuals recall in the absence of any cues or directions.

One of the important findings reported by using free recall is the serial position effects. In 1962, Murdock calculated the probabilities of each position in the study list to be recalled and reported the serial position effects. The enhanced recall performance for the beginning and the end of the list are called primacy and recency effect, respectively.

Another effect reported in the episodic memory is the contiguity effect. The contiguity effect can be defined as the increased probability of recalling a close by item after the initial recall (Kahana, 1996). This effect can be quantified by using the lag-CRP analysis. In this analysis lag is the positional difference between two recalls and Conditional Response Probability is calculated by dividing the number of recall transitions made for each lag by the number of possible transitions for that lag.

Individual Differences and Experimental Manipulations

Even though the size of the effect changes due to personal differences, the effect was reported to be present for 96-100% of participants depending on how it was measured (Healey & Kahana, 2014). Also, several research indicates the contiguity effect changes with age, increasing in childhood and decreasing in elderly (Lehman & Hasselhorn, 2010; Healey & Kahana, 2016; Healey et al., 2019; Kahana et al., 2002; Wahlheim et al., 2017). Furthermore, there are studies indicating the size of the contiguity effect is positively correlated to overall memory performance, and IQ (Healey et al., 2014; Sederberg et al., 2010; Spillers & Unsworth, 2011).

Experimental manipulations that may affect the contiguity effect can be classified into three: task manipulations, stimuli manipulations and encoding manipulations (Healey et al., 2019). Some examples of task manipulations include changing the learning or recall modality, study list length and inter-stimulus interval. Several studies indicated although these manipulations can change the size of the contiguity effect, it is still robust to diminishing (Healey et al., 2019; Murdock, 1962; Murdock & Walker, 1969; Nguyen & McDaniel, 2015).

Similarly, some examples of stimuli manipulations include the stimuli characteristics such as word frequency, orthographically distinctiveness, emotional valence, stimuli type, picture or word for example, and semantic relations. Similar to task manipulations, nearly all stimuli manipulations affect the size of the contiguity effect, but don't cause it to flatten (Cortis et al., 2015; Cortis Mack et al., 2018; Long et al., 2015; Miller et al., 2013; Nguyen & McDaniel, 2015; Polyn et al., 2011; Siddiqui & Unsworth, 2011; Ward et al., 2003).

Lastly, some manipulations to the encoding process can be done. For example, levels of processing might be manipulated with different tasks, mnemonic strategies might be enforced, or the effect can be investigated when there are no encoding instructions, as in the incidental encoding studies. Even though mnemonic strategies tend to increase the contiguity effect, results of incidental encoding and levels of processing studies are more complex (Bouffard et al., 2018; Healey, 2018; Mundorf et al., 2022; Nairne et al., 2017).

Long-Term Contiguity Effect

Even though the inter-stimulus interval in the studies mentioned so far is limited to seconds, in real life, this interval is much longer. In this section, long-term contiguity effect will be discussed.

In one experimental set up, participants may be gi-

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ven several study lists and a test after each list, asking them to recall only words from the list they just studied. Murdock (1974) examined the errors people make and concluded that when people recall from another list, it tends to come from a nearby list, resulting in the long-term contiguity effect. This result is replicated when some words are repeated in several lists (Zaromb et al., 2006).

Another experimental set up might include providing only one recall task, after the completion of several study lists. In such a recall tasks consecutive recalls might be from the same list or different lists. Long term contiguity effect is seen when consecutive recalls from different lists come from close by study lists, compared to further ones (Healey et al., 2019; Howard et al., 2008; Unsworth, 2008). In a similar study, participants were again given several study lists, and one recall task at the end, but with probes. In the probed recall task, participants are given words from the study lists, asked to make a recognition judgement, then asked to recall another word from the same list (Kılıç et al., 2013). The long-term contiguity is seen when individuals erroneously recall from another list, and that list is positioned close by to the probe's study list.

Mechanisms to Explain the Contiguity Effect

Insofar several findings regarding the contiguity effect were presented. Even though several manipulations and interpersonal or group differences can change the size of the effect, it is reported to be robust, and, also, reported in long term. There are several mechanisms proposed to explain the effect. Even though none are fully capable of explaining all findings, several models, using more than one of those mechanisms explain different aspects of the contiguity effect adequately.

One proposed mechanism to explain the contiguity effect is the short-term memory. The first ever memory model was proposed by Atkinson and Shiffrin (1968) as a three store model, known as the Multi-Store Model or the Modal Model. the model consisted of sensory memory, short-term memory, whereas long-term memory, and later versions included only the latter two and were classified as Dual Store Models of Memory (Atkinson & Shiffrin, 1971). Some of these models suggest that the relationship between near items strengthen as they spend time in the short-term store and this leads to the contiguity effect (Kahana, 1996).

Another mechanism is associative chaining. This perspective assumes that consecutive items in the study lists are associated with each other, and temporal information is encoded by the association between near items, and explain the contiguity effect this way (Lewandowsky & Murdock, 1989; Solway et al., 2012). Whereas according to the positional coding perspective, for each encoded item, position of that item is also encoded, and these positional codes are used in retrieval as cues (Burgess & Hitch, 2006; Farrell & Lewandowsky, 2002). Since positional codes of near items are similar to one another, next recall is likely to be from a near position, leading to the contiguity effect.

According to the chunking perspective, items learned in temporal proximity are more likely to be in the same chunk, compared further items, and since they share a similar temporal code, they are more likely to be recalled consecutively, leading to the contiguity effect (Farrell, 2012). On the other hand, some researchers suggest that control processes can lead to and explain the contiguity effect (Atkinson & Shiffrin, 1968; Lehman & Malmberg, 2013; Unsworth, 2016). One example of these control processes might be creating stories to remember the order of the studied items.

Lastly, one commonly used explanation is the usage of context. Some models claim that context, which changes when a change happens in the environment, is coded with each studied item and recalled with the item during retrieval (Murdock, 1997; Tulving, 1972). Since the contexts of near items are more similar, the next recalled item is likely to be placed near to the previous recalled item in the study list, leading to the contiguity effect.

Models to Explain the Contiguity Effect

Models trying to explain the contiguity effect can be classified into two as causal and noncausal models (Kılıç et al., 2013). Noncausal models propose that the contiguity effect is caused by the similarity of mental states during the study and the test phases (Davelaar et al., 2005). On the other hand, causal models, such as SAM or TCM, propose that each recalled item and its context is used as a cue for the next recall. One study, that aims to differentiate between these models, developed the probed recall task (Kılıç et al., 2013). In the probed recall task, after studying multiple lists, participants are presented with either words that they studied or new words and asked to make a recognition judgment. Later, if the word was old, they are asked to recall another word from the same study list. With the presentation of probes, the similarity of mental states during the study and test phases are disrupted. The results of the study indicated that even when the similarity is disrupted both short-term and long-term contiguity effects remains robust, supporting the causal accounts. However, the lack of asymmetry in the contiguity effect and the low performance of individuals suggest further research needs to be done.

Conclusion

This review has examined how the magnitude of the effect varies across tasks, stimulus properties, encoding manipulations, and individual differences, and how different mechanisms and models attempt to explain it. Evidence suggests that the contiguity effect is not a task- or population-specific artifact but a robust phenomenon observed across nearly all individuals and strongly present even in initial recall attempts,.

A key point is that, compared to other memory phenomena such as recency, the contiguity effect is highly resilient: its magnitude may vary with experimental manipulations or individual factors (e.g., age, clinical conditions, experience), but it rarely disappears. Moreover, it is not limited to free recall; it has been reported in recognition tasks, remember/know judgments, false recalls, inter-list transitions, and even at long timescales where items are separated by hours or days.

While current episodic memory models can explain important aspects of the effect, none yet fully captures all empirical findings. In particular, asymmetry, long-range contiguity, and changes observed in clinical populations require more comprehensive modeling. Expanding current models to integrate semantic, emotional, and spatial contexts (e.g., CMR, e-CMR) is a promising direction, but such extensions must also clarify the mechanisms underlying performance differences across populations and tasks.

Future research should also move beyond highly controlled laboratory tasks using word lists. Naturalistic paradigms, such as experience sampling, lifelogging with wearable cameras, or virtual reality, can provide ecologically valid insights into how spatial, semantic, and emotional contexts interact with temporal contiguity in everyday memory. Furthermore, model-based parametric analyses may help reveal the mechanistic origins of age-related or clinical differences. Finally, refining and extending paradigms like probed recall (Kılıç et al., 2013) across different materials, contexts, and task formats will be crucial for distinguishing between causal and non-causal accounts of the contiguity effect.

In sum, the contiguity effect is a robust phenomenon observed both in the laboratory and in everyday life, resistant to many manipulations and individual differences. Understanding and modeling this effect is critical for advancing our understanding of episodic memory as a whole.